Guide 74

Briefing the design team for energy efficiency in new buildings

THE PURPOSE OF THE GUIDE

This Guide aims to help clients of new building projects, and their design team, to achieve energy efficient buildings, whether on redevelopment or green field sites.

It provides information on all the main aspects of energy efficiency which need to be considered in the design, construction, and operation of the building. It indicates at which stage in the process they need to be considered, what design options are available, and how to ensure that the energy efficiency performance is maintained over the life of the building.

INTRODUCTION

With the support of an informed design team, an enlightened client can become the owner of an attractive and stimulating building, which is also energy efficient.

The most energy efficient building is the one which provides the specified internal environment for the minimum energy cost.

The approach advocated in this Guide will lead to a more energy efficient building. It also offers other significant benefits to the owner, occupier and the country.

Energy efficient buildings:

- provide users with a healthy, comfortable environment which is stimulating for work, leisure or recreation
- contribute to the nation's 'green' initiative by helping to reduce carbon dioxide emissions and the threat of global warming
- need cost no more than conventional buildings to construct
- can attract a premium in the market-place, and are increasingly likely to do so
- are efficient to operate with low running costs.

This Guide has been developed in collaboration with the Royal Institute of British Architects and is endorsed by the Royal Town Planning Institute.

"The client's role in briefing their design team is crucial in achieving an energy efficient building"

BEST PRACTICE PROGRAMME

Energy Efficiency Office
DEPARTMENT OF THE ENVIRONMENT

KEY MANAGEMENT ACTIONS

The key management actions needed for clients to achieve a successful project are listed:

Design team

- Appoint the whole design team early. Establish aims and consider all options. Where possible, quantify energy efficiency targets and environmental design credits under the BREEAM Assessment Method.
- Refer to BRE Report BR 95 "Better briefing means better buildings", for guidance on the client's role in building projects.

Integrated design approach

- Ensure that an integrated approach to design is taken, where members of the design team work closely together to realise the aims and design targets for the building. An integrated approach will enable energy efficient features to be incorporated at little or no extra cost.

Specification

- Ask for the specification to be no more sophisticated than is appropriate for the use of the building. Since occupants usually prefer naturally ventilated buildings and good daylighting, avoid the unnecessary use of air-conditioning or unduly high levels of artificial lighting.
- Choose the simplest possible services concept which will give the required internal conditions, so that capital cost is minimised, plant operation is easier and maintenance costs are reduced.

Timing of design decisions

- Ensure that outline proposals are formulated and detailed decisions made on the key design options at an early enough stage in the project. Whilst it is vital for some design decisions to be made early, others may be delayed until later. The iterative nature of design should be acknowledged.
- Table 1 illustrates the stages at which each of the main topics that influence the achievement of an energy efficient and environmentally sound design need to be addressed.

ENERGY DESIGN ADVICE SCHEME

Specialist advice on energy efficient design is available from regional centres throughout the country to clients and their design team through the Department of Trade and Industry's Energy Design Advice Scheme (EDAS).

These centres make available the results of the DOE's Best Practice, the DTI's Passive Solar, BRE's, the European Commission's and the International Energy Agency's programmes. EDAS operates two levels of advice. Firstly, the centre staff may give up to one day's free advice. Secondly, where further advice will increase the likelihood of energy savings, EDAS will recommend energy consultants whose fee will be subsidised up to 50%.

The telephone numbers of the EDAS regional centres are listed on the back page of this Guide.

Main topics affecting energy efficiency	Stages in the project			
	Inception and feasibility	Formulation of brief	Design and construction	Handover and occupation
Energy efficiency targets	P	D	R	R
Environmental impact	P	D	R	R
Economic appraisal	P	P	D	
Site location	D	R		
Site layout	P	P	D	
Building form and features	P	P	D	
Building fabric		P	D	
Services and controls		P	D	R
Management procedures		P	D	O

Notes: P = Preparation of outline proposals
D = Detailed decisions on design, specification, cost or operation of the building
R = Review of decisions as part of the iterative design process
O = Implementation of operational procedures, monitoring and feedback

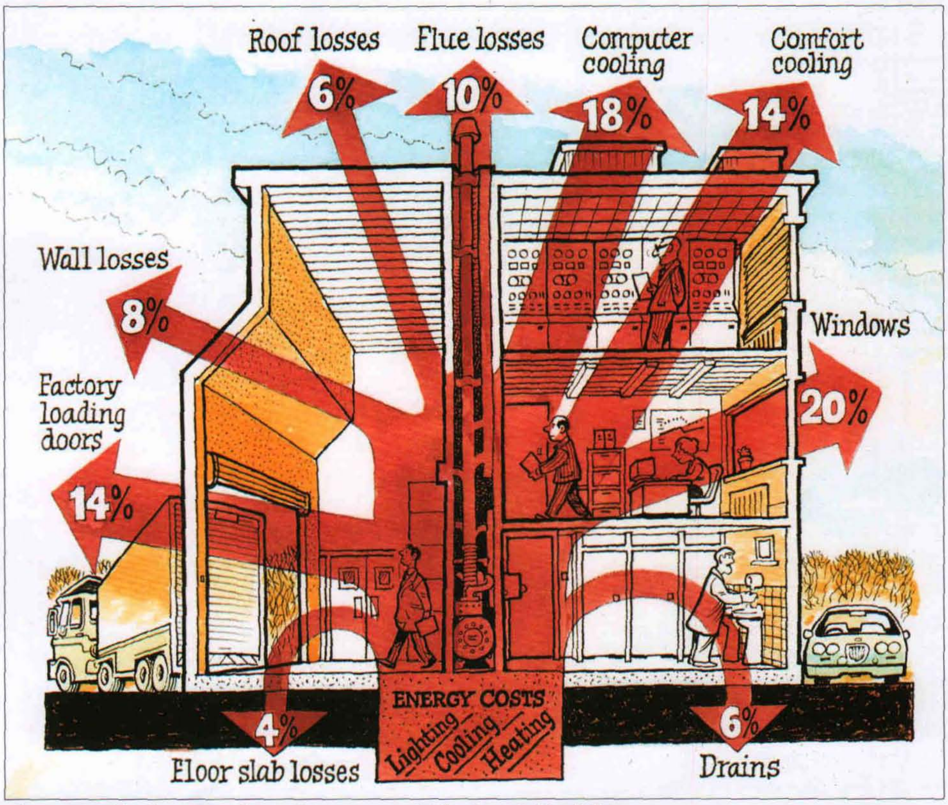
Table 1 Stages at which main topics need to be addressed

THE CLIENT'S ROLE

Client direction is essential at each stage of the project.

- **At the outset**, the choice of site has a major effect on energy use and one that may be impossible to put right if mistakes are made. Clients should appoint their whole design team early and ask for alternative sites to be fully evaluated.

  At the earliest possible stage contact should be made with the local authority, planning officers and building control officers, to seek their reaction to the site and the likely design. Any energy efficiency design features should be explained and discussed at this stage.
- **At the briefing stage**, the client's view of how the building will be used affects many decisions. The design team should assess the client's needs and agree appropriate energy and environmental performance targets.
- **As the design is developed**, the client should require the team to demonstrate that the agreed energy and environmental performance targets will be achieved.
- **During construction**, the client should see that quality control is maintained so that the energy efficiency potential of the design is realised in the finished building.
- **At handover**, the client should ask for evidence that the building services are correctly commissioned. The manager of the building should be trained and qualified to operate the plant and ensure it is properly maintained.



An example of energy flows in commercial/industrial buildings

This office building for Ernst and Young has high frequency lighting with effective central and local control

Ventilation and air-conditioning

Energy use in naturally ventilated buildings is significantly less than in air-conditioned buildings due to a substantial reduction in electricity consumption (see figure 2). EEO Good Practice Guide 34 gives further details of energy use and costs, as well as information on formulating a brief for energy efficient offices.

- Consider the use of natural ventilation first; most occupants prefer to control their own fresh air supply in summer by opening windows. It is often possible to avoid the need for mechanical ventilation and air-conditioning, although some designs which are essentially naturally ventilated can benefit from fans to assist in air movement when natural conditions are unfavourable.
- For naturally ventilated buildings, specify controllable background ventilation, eg by 'trickle' ventilators or fanlights.
- Specify windows that are simple to operate.
- Consider mechanical ventilation systems if natural ventilation is impractical due to external noise levels or pollutants. Options for summer include 'free' cooling when the outside air temperature is below the required internal temperature, 'night-time' ventilation with cool night air and, in winter, heat recovery.
- Consider partial air-conditioning before full air-conditioning. 'Mixed mode' designs allow different parts of the building to be ventilated in different ways at different times. In this way some areas can remain mechanically or naturally ventilated while others are fully air-conditioned. Spaces that are air-conditioned can revert to natural ventilation at other times, for example by opening windows. Refer to CIBSE Guide B and EEO Good Practice Guide 71 "A guide for building clients and their advisers – selecting air conditioning systems".
- For smokers, provide extract ventilation separate from air recirculation in air-conditioned buildings.

Lighting

Artificial lighting is often the largest individual item of energy cost. Savings can be achieved by exploiting daylight to displace artificial lighting. Careful design of the size and location of windows, as well as the choice of colour in internal finishes, can ensure that lighting demands are met from daylight for a substantial part of the year.

- Use light colours internally to help to achieve the required lighting levels.
- Choose the size of windows on each façade carefully, depending on orientation. EEO Good Practice Case Study 62 describes how the choice was made for the Low Energy Office at BRE. CIBSE Applications Manual (AM2) provides guidelines on the choice of window area.
- Choose appropriate standards but do not over light. Special needs for additional lighting should be met locally and not for the entire area. BRECSU can provide other EEO Best Practice publications and EC THERMIE lighting guides for more information.
- Specify efficient lamps and fittings. Most areas can be lit using no more than 2.5 W/m^2 of installed lighting power (including control gear) per 100 lux of illuminance. New technology has made lamps, reflectors and control gear much more efficient. Reductions of 50% and more in installed power are common relative to older systems. Use tungsten or tungsten-halogen lighting very sparingly. Where considering high intensity discharge lighting, remember the lamps take several minutes to warm up and restart and so will tend to be left on unless special provision is made.
- Consider automatic controls, particularly for lights in open areas. Try to adopt a policy of manual ON/OFF but with automatic OFF providing a reminder/backup. Integrate automatic controls with daylight where possible. Provide local switches so that users can easily control their own lighting.
- Consider occupancy sensing controls in intermittently-used areas where lights will tend to be left on otherwise.
- Specify that circuits should allow sub-metering of individual zones or floors of the building.

Heating

Once the requirement for heating has been minimised by the overall design of the building, coupled with the insulation and airtightness of the building fabric, the key to energy efficient heating lies in the use of efficient boiler plant and appropriate control systems. Contributions to heat input can also be derived from the recovery of heat from exhaust air or from the use of solar energy.

This Hampshire County Council school at Netley uses solar preheating of ventilation air through a conservatory to satisfy 40% of the space heating requirement

- Specify efficient boiler plant. Condensing boilers, gas or oil-fired, are the most efficient for space and water heating. They are cost-effective in many applications, particularly where they can be used as the lead boiler in a multi-boiler installation.
- Consider combined heat and power (CHP) for buildings which have a reasonably constant requirement for heat and power, eg hospitals, hotels and leisure buildings.
- Provide effective central, zone and room controls. Consider separate systems to meet small loads, such as independent water heaters for summer use.
- Consider heat recovery. Note that the cost of the additional electricity used will need to be set against the value of the heat saved.
- As well as for lighting, use can sometimes be made of the sun's energy for heating, either by using windows to benefit directly from solar energy, or by using solar energy to pre-heat ventilation air. It is important to balance these potential benefits with the additional heat loss in winter and any solar gains in summer. The EEO GPCS 62 gives an example of this approach.
- Consider shading devices to avoid excessive heat gain in summer or glare close to windows. These may be either fixed to the outside of the building, such as fins or moveable, such as Venetian blinds.

Controls and monitoring

Controls need to be readily understood by those who will use them. It follows that controls should be simple to operate, and located where they are easily accessible.

- Provide controls which enable occupants to control their local environments and allow them to override automatic controls where these are fitted.
- Match controls to the intended usage or tenancy patterns.
- Make sure that devices requiring regular re-setting and re-programming are readily accessible to the people responsible.
- Specify adequate and accessible metering and sub-metering facilities to effectively identify the energy use in each zone or floor of the building.

MANAGEMENT PROCEDURES

Good management of the building is an essential part of achieving energy efficiency. Those responsible for management and maintenance should ideally be involved in the design and commissioning processes.

- Obtain good record drawings and operation and maintenance manuals.
- Train staff in the operation of the building at handover.
- Make a Corporate Commitment to energy efficiency (see box on the back page).
- Set up energy monitoring and management procedures. Regularly review fuel bills and sub- meter readings and set targets for reductions.
- Carry out regular energy audits and surveys to ensure that energy use is under control. CIBSE Applications Manual (AM5) gives detailed guidance.

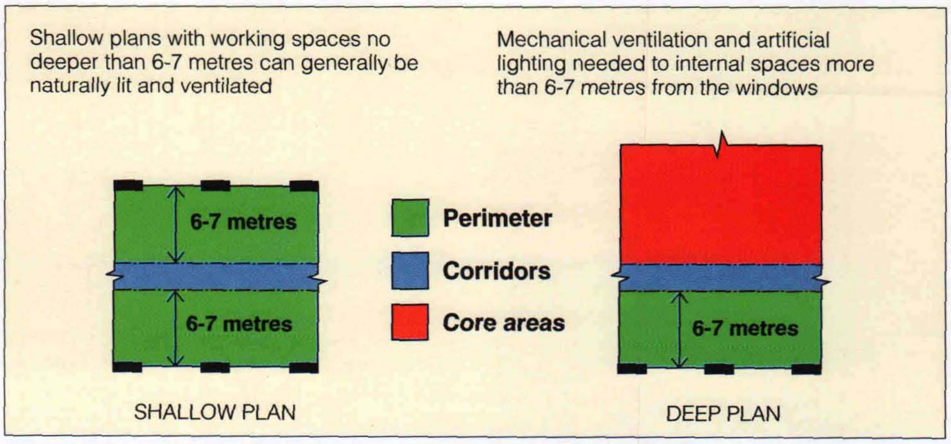


Figure 1 The relationship between plan form and ventilation method

External angled shelf used at South Staffordshire Water Company building to equalise daylighting levels and provide solar shading

- Choose a redevelopment site in preference to a green field site, since this conserves scarce natural resources.
- Take advantage of heat sources close to the site if available, eg from a local district heating scheme or waste heat from processes. Also consider any limitations of the existing energy supply infrastructure.

SITE LAYOUT

- Use the natural characteristics of the site, slopes, belts of trees, earth mounds, to best advantage. Trees and earth mounds provide not only shelter from cold winds but also noise protection, and south facing slopes make it possible to derive maximum benefit from solar heat gain.

BUILDING FORM AND FEATURES

The careful design of the form of the building, its detailed features and internal planning can reduce artificial lighting, heating, cooling and ventilation loads.

- Design the building structure so that the required internal conditions can be achieved with minimum reliance on services.
- Consider the depth of the building. Deep plans are less easy to light and ventilate naturally than shallow plans with daylit spaces up to 6-7 metres from windows (see figure 1). Courtyards and atria can be used to introduce light and air into the centre of buildings.
- Make use of windows to benefit from daylight and, where possible, solar gains. One way in which glare can be controlled and daylighting levels equalised throughout the space is to incorporate a suitably angled shelf into the window design.
- Place activities which benefit most from daylight and natural ventilation near the perimeter. Spaces which are infrequently occupied or require mechanical ventilation or air-conditioning for functional reasons can be placed towards the inside, or used to protect other parts of the building from noise, eg from an adjacent road.
- Carefully consider the height of the building. Walls enclosing the top storeys of high buildings are more exposed to cold winds than those of low buildings and consequently suffer greater heat loss from air leakage. Sealed windows may be needed on higher floors, placing greater reliance on mechanical ventilation.

BUILDING FABRIC

The term building fabric refers to the internal structure and the external elements (roof, walls and floors) of the building. It is the insulation and airtightness of the external elements which determines the rate of heat loss, but the characteristics of the inside of the building can also have an influence on the use of energy.

It is important to remember that the fabric of the building is not easily upgraded over the life of the building, whereas the services are often completely replaced. In many cases, high levels of insulation, better than that required by the Building Regulations, will be beneficial and cost-effective.

Air leakage through gaps and cracks causes unnecessary heat loss, as well as discomfort for occupants of the building.

- Insulate the building to the optimum level taking account of the capital cost of the insulation and the value of energy savings.
- Ensure that air leakage is minimised. Attention to detail at both the design and construction stages is essential. Consider providing draught lobbies at busy entrances.
- Specify double glazing for all windows.
- Sealed glazing units, with low emissivity glass, should be considered for their thermal comfort benefits.
- Design the structure to be sufficiently exposed so that its thermal mass will absorb solar gains and delay peak internal temperatures until the occupants have left the building, reducing the need for air-conditioning or at least its capacity.
- Refer to the BRE Report "Thermal insulation: avoiding risks" for detailed guidance on avoiding thermal bridging, minimising air leakage and the specification of sealed glazing units.

SERVICES

Services should form an integral part of the design concept of the building, not as the means of creating satisfactory internal conditions within a poorly designed building structure. It is important therefore that the Building Services Engineer is involved early on.

Avoid making the performance specification for the internal environment too tight, eg by specifying unnecessarily narrow limits for internal temperature. Do not use more complex technology than necessary to solve the problem effectively. This can create unnecessary maintenance or management burdens.

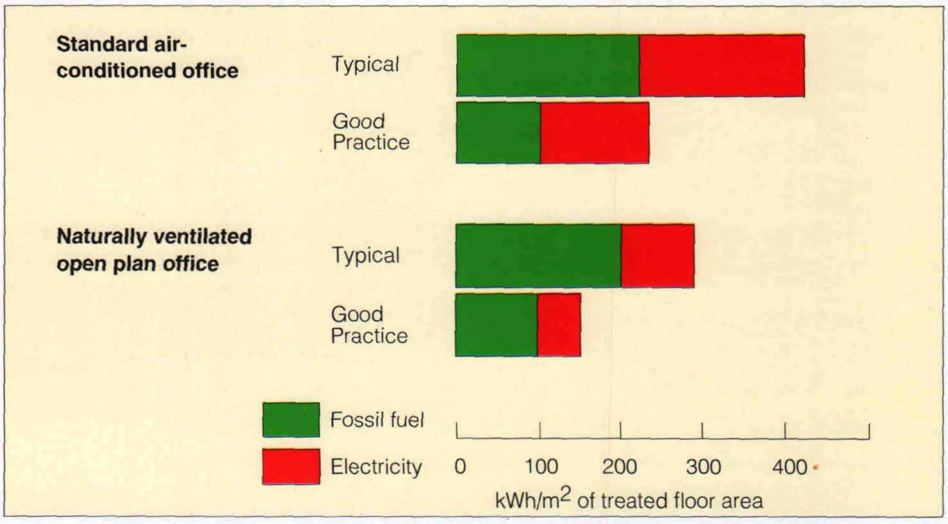


Figure 2 Annual energy use in typical and good practice offices

ENERGY EFFICIENCY TARGETS

If energy efficiency principles are followed, up to 40% savings in energy use are possible compared with typical buildings of the same type.

EEO Best Practice programme publications give an indication of energy consumption and fuel cost performance for typical energy efficient buildings. The performance figures, which are expressed in a variety of units depending on building type, may be taken as reasonable annual performance targets. Examples are:

Offices

Naturally ventilated
- cellular £3.66/m^2
- open plan £5.00/m^2

Air-conditioned
- standard £8.47/m^2
- prestige £14.64/m^2

NB: Costs are at 1990/91 prices for treated floor area (gross area less spaces not directly heated).

Schools

Primary £17/pupil
Secondary £30/pupil
NB: Costs are at 1989/90 prices.

Industrial Buildings

General manufacturing £5.63/m^2
NB: Costs are at 1993 prices.

Hotels

Luxury £390/bedroom
Business £340/bedroom
NB: Costs are at 1993 prices.

For copies of relevant Energy Consumption Guides (and advice on targets), contact BRECSU.

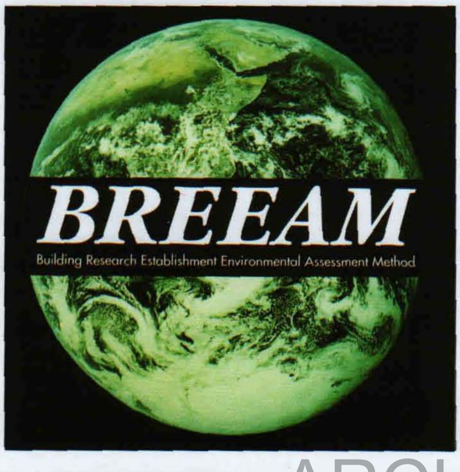
Energy targets have also been set at a more detailed level. For example, most buildings can be lit using no more than 2.5 W/m^2 of installed lighting power (including control gear) per 100 lux of illuminance. Similarly, recommendations have been made for fan power per cubic metre of ventilation air.

Ask your design team to demonstrate that their design will achieve the appropriate energy efficiency target.

ENVIRONMENTAL ASSESSMENT

The Building Research Establishment's Environmental Assessment Method, BREEAM, is a method of assessing the environmental quality of buildings. Its main objectives are to:

- enable developers, designers and users to respond to a demand for buildings which are friendlier for the environment, and then to stimulate such a market



Points for comparison	100 W tungsten filament	20 W compact fluorescent
Lamp life	1000 hours	8000 hours
Number of replacement lamps over 8000 hours	8	1
Cost of replacement lamps over 8000 hours	£4	£14
Running cost over 8000 hours with electricity at 7.5p/kWh	£60	£12
Total life cycle cost	£64	£26
Saving of compact fluorescent over tungsten filament	**£38**	
Note: A 20 W compact fluorescent lamp has the same light output as 100 W tungsten filament lamp.		

Table 2 An example of a simple economic appraisal

- raise awareness of the great importance of buildings in global warming, acid rain and the depletion of the ozone layer
- set targets and standards which are independently assessed
- reduce the long term impact buildings have on the environment
- reduce the use of increasingly scarce resources such as water and fossil fuels
- improve the quality of the indoor environment of buildings and hence the health and well being of their occupants.

The choice of fuel is also a significant environmental issue, since it has a direct impact on carbon dioxide emissions.

The scheme is voluntary and the assessments are carried out by independent assessors licensed by the Building Research Establishment (BRE). The conclusions of the assessment are confirmed in the form of a certificate which identifies where the building has satisfied the criteria set for individual environmental impacts.

Carrying out the two stage assessment early in the design process allows the assessor's recommendation for improvements to be incorporated before the design is fixed. The assessment gives credits where satisfactory attention has been paid to:

- global effects – carbon dioxide emissions, acid rain, ozone depletion
- neighbourhood effects – re-use of sites, micro-climate, risk of Legionnaires' disease from air-conditioning cooling towers
- indoor effects – risk of Legionnaires' disease from hot water systems, use of hazardous materials, indoor air quality.

Ask your professional team to follow the principles described in the BREEAM method. If available for the building type, have an assessment made of the design. This assessment will provide useful information when pursuing compliance with BS 7750 "Specification for environmental management systems".

ECONOMIC APPRAISAL

It is important to take a long term view which takes the running and replacement cost as well as capital cost of an energy efficiency option into account. For example, table 2 illustrates the financial benefit of a compact fluorescent lamp over a traditional tungsten filament lamp with the equivalent light output, when the life cycle costs are calculated.

Ask your professional team to undertake an investment appraisal of energy efficiency options and adopt those that show the least life cycle cost.

The appraisal technique chosen should be relevant to your circumstances. A comparison between alternative techniques is shown in the box below.

Alternative investment appraisal techniques

Simple payback period is the time over which the net actual savings add up to cover the initial cost. It does not take account of the benefits of savings following the payback period.

Net present value (NPV) is the sum of the present values of all costs and savings using a standard discount rate. Including a discount rate ensures that savings in the future do not have an exaggerated value.

Discounted payback period is similar to a simple payback except that the NPV of the savings is used. This is a widely used and respected investment appraisal technique.

NPV per unit of capital cost (K), ie NPV/K. This provides a means of choosing between alternative investments. Those with the highest value of NPV/K are to be preferred.

Internal rate of return (IRR) or 'yield' is the discount rate which makes the NPV zero. This gives a single easily understood figure analogous to a return on investment

SITE LOCATION

It is vital to be aware that the choice of site and the broad layout of buildings within it can have fundamental implications on the energy efficiency and environmental impact of the project. Once made, these decisions are usually irreversible.

- Locate sites close to public transport. Reducing reliance on private transport, both for supplies and personnel minimises the use of fuel and helps to reduce pollution. DOE guidance advocates that planning authorities should guide new development to locations which reduce the need for car journeys (Planning Policy Guides 12 and 13). This strategy also reduces the need to provide car parking on site.

This advance factory unit used by Barclays Bank as a warehouse uses about 40% less energy than an average factory unit, using automatic lighting controls to reduce electricity consumption

- Match performance standards and operating hours to user needs.
- Check control functions regularly.
- Encourage and motivate staff to reduce energy wastage, for example by turning lights off and closing windows when heating is on.
- Avoid excessive complication, beyond the normal capabilities of staff and maintenance personnel.
- Ensure that the design team receives feedback on how effective their design has been in achieving the energy efficiency targets.

CONCLUSION

This Guide has outlined how the client can help to achieve an energy efficient and environmentally sympathetic building. It has also summarised the issues that the design team should address during the development of the project.

If your design team is not expert in the principles and practice of energy efficiency, a wealth of information is available from BRECSU and other sources. Some references are listed on this page along with sources of additional information.

Help in the design of your own particular project is available from energy efficiency specialists through the Energy Design Advice Scheme. The availability of this scheme should give you greater confidence to adopt an energy efficient approach for your next building project.

MAKING A CORPORATE COMMITMENT

Companies and public sector organisations may join over 1600 others in the EEO's Making a Corporate Commitment campaign to achieve financial and environmental benefits from responsible energy management. On joining the campaign, a senior board member signs a Declaration of Commitment which covers a number of elements, eg publishing a corporate policy, appointing an Energy Manager, setting performance targets and increasing energy awareness amongst staff.

ADDITIONAL INFORMATION

Additional information can be obtained from:

Royal Institute of British Architects
Client Advisory Service
Portland Place
London W1N 4AD
071 580 5533

Royal Incorporation of Architects in Scotland
15 Rutland Square
Edinburgh EH1 2BE
031 229 7545

Royal Institute of Ulster Architects
2 Mount Charles
Belfast BT7 1NN
0232 323760

Chartered Institution of Building Services Engineers
Delta House
222 Balham High Road
London SW12 9BS
081 675 5449

Royal Institution of Chartered Surveyors
12 George Street
Parliament Square
London SW1P 2AD
071 222 9430

Royal Town Planning Institute
26 Portland Place
London W1N 4BE
071 636 9107

Building Research Establishment
To obtain BRE publications contact:
Bookshop
Garston
Watford WD2 7JR
0923 664444

To commission a BREEAM assessment contact:
BREEAM – MDO
at the above address or
Tel 0923 664462 Fax 0923 664088

REFERENCES

Best Practice publications

There is a wide range of EEO Best Practice publications for different types of buildings not listed here. Information on these is available from BRECSU Enquiries Bureau (see below)

The EEO publications referred to in this Guide are:

Good Practice Guides

GPG 34 Energy efficiency in offices – A guide for the design team

GPG 71 Selecting air-conditioning systems – A guide for building clients and their advisers

Good Practice Case Studies

GPCS 21 Energy efficiency in offices – One Bridewell Street, Bristol

GPCS 62 Energy efficiency in offices – BRE Low energy office

GPCS 106 Energy efficiency in Advance Factory Units – Barclays Bank plc, Milton Keynes

Energy Consumption Guides

ECON 17 Saving energy in schools – The Local Authority Chief Officers' Guide to Energy Efficiency

ECON 18 Energy Efficiency in Industrial Buildings and Sites

ECON 19 Energy efficiency in offices – A technical guide for owners and single tenants

ECON 36 Energy Efficiency in Hotels – A Guide for Owners and Managers

Building Research Establishment

BRE Report BR95
"Better briefing means better building"

BRE Report BR143
"Thermal insulation: avoiding risks"

BREEAM Version 1/93
An environmental assessment for new office designs

BREEAM 2/91
An environmental assessment for new superstores and supermarkets

BREEAM Version 3/91
An environmental assessment for new homes

BREEAM Version 4/93
An environmental assessment for existing office buildings

BREEAM Version 5/93
An environmental assessment for new industrial, warehousing and non-food retail units

ENERGY DESIGN ADVICE SCHEME CONTACT POINTS

Edinburgh	Tel: 031 228 4414 Fax: 031 228 2188
Belfast	Tel/Fax: 0232 364090
London	Tel: 071 916 3891 Fax: 071 916 3892
Sheffield	Tel: 0742 721140 Fax: 0742 720676